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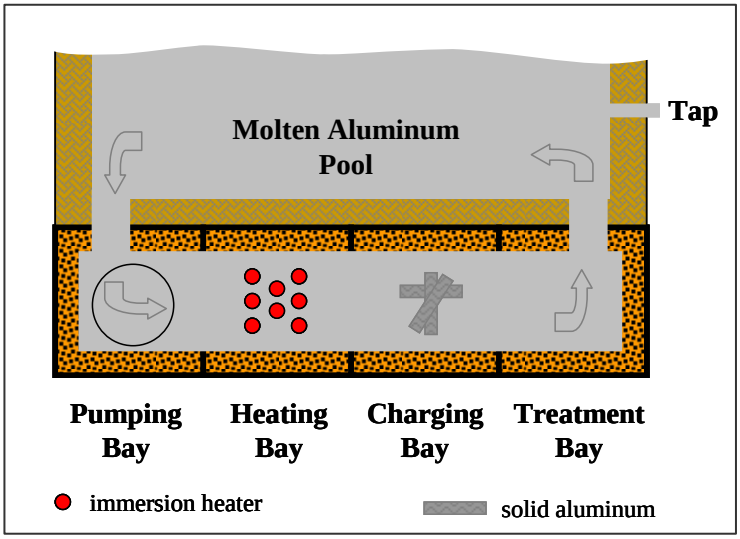
Energy-Efficient Isothermal Melting of Aluminum

Isothermal melting (ITM) is a system that uses immersed electric heaters (97% conversion from electricity to heat) to melt metal by heat conduction. “Isothermal” (means “constant temperature”) refers to its unique ability to maintain the molten pool temperature approximately the same throughout. This feature eliminates the need for much higher temperatures (requires lot more energy!) with traditional gas-fired furnace that melts metal by heat radiation.



Today the majority of aluminum is melted in low-efficiency (~30%) gas furnaces. Approximately 67 trillion Btu (TBtu) are consumed to melt and hold the 32 billion pounds of molten aluminum annually in the United States to produce ingots, sheets, plates, extrusions and castings. *Gas furnaces use ~2,100 Btu/lb to melt aluminum and lose ~2-4% of the metal to oxidation. ITM uses less than 650 Btu/lb to melt aluminum and reduces oxidation losses to < 1%. It is estimated that ITM will save 50% of the energy and reduces the emission by 80% (incl. losses from electricity generation and transmission, and savings from reduction of metal oxidation).* With a 60% market penetration in 2020, ITM would save approximately 18.6 trillion Btu and reduce emissions by over 180,000 metric tons of carbon equivalent.

What makes ITM so efficient is the use of immersion heaters in its multiple bays. Each bay contributes to an efficiency improvement. The pumping bay provides good circulation in the isothermal systems. This circulation promotes better mixing for purifying and alloying, and more uniform temperature profiles throughout the molten pool. The heating bay is the major source of efficiency gain, where electricity is converted into heat through the immersion heaters and conducted directly to the molten metal. The heating bay raises the molten metal temperature (typically less than 90°F) just high enough to melt the solid metal being charged into the pool. The charging bay and treatment bay provide more compact areas to control and introduce solid charge or alloying and purifying elements compared to opening a heath door and exposing the entire surface of the pool and refractory to the plant environment.

The challenge to developing the ITM system was the creation of immersion heaters that could provide the high heat flux and the chemical, thermal and mechanical robustness required in an industrial molten aluminum environment. Apogee Technologies’ research program developed new materials, fabrication techniques and quality control systems to build immersion heaters with high heat flux (approximately 70,000 Btu/hr-ft^2), approximately 5 to 10 times more than commercially available heaters, and with external coatings that provide protection from highly corrosive molten aluminum.

Apogee and Aleris began testing a 5,000 lb/hr ITM system at Aleris’ plant in Ohio since October 2005. The initial results confirm their expectations: <650 Btu/lb and <1% metal loss to oxidation. ITM systems offer economically attractive alternatives to both new furnace construction and retrofit. ITM systems have lower capital and operating costs and a significantly smaller foot-print. A retrofit onto an existing system can increase capacity while lower energy use and emissions. In addition, the ITM immersion heaters developed have crosscutting applications throughout aluminum, copper, glass, steel, and molten metal industries.

Project Partners:

- Apogee Technology, Inc., Verona, PA
- Aleris International, Inc., Newport, OH
- Drexel University, Philadelphia, PA